March 27, 1962 R. J. ZIEHLKE 3,026,757

TRANSIENT FILTER

Filed Nov. 24, 1958 2 Sheets-Sheet 1

Fig. 1.

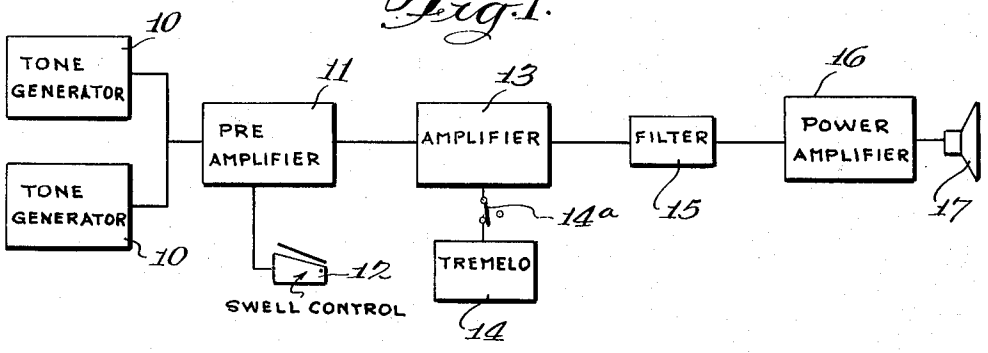


Fig. 3.

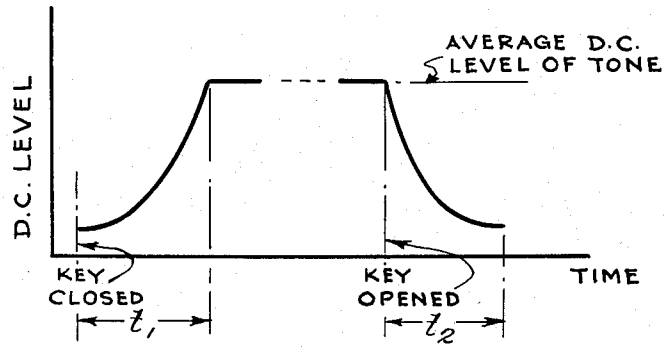
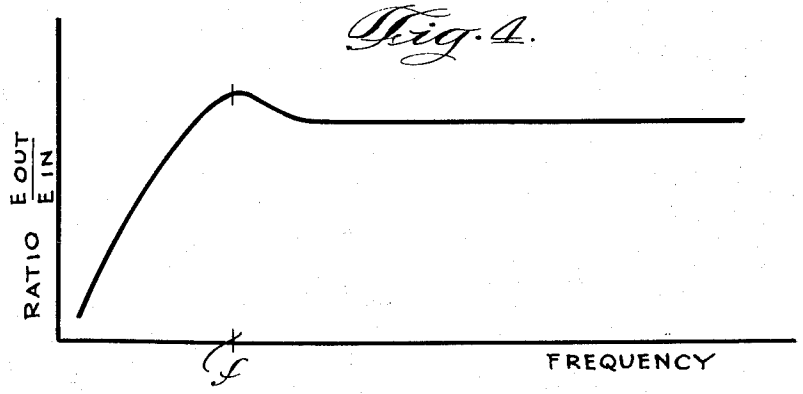


Fig. 4.



INVENTOR.
Robert J. Ziehlke
BY
Schroeder, Hoffman, Brady & Wegner
attorneys

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TRANSIENT FILTER

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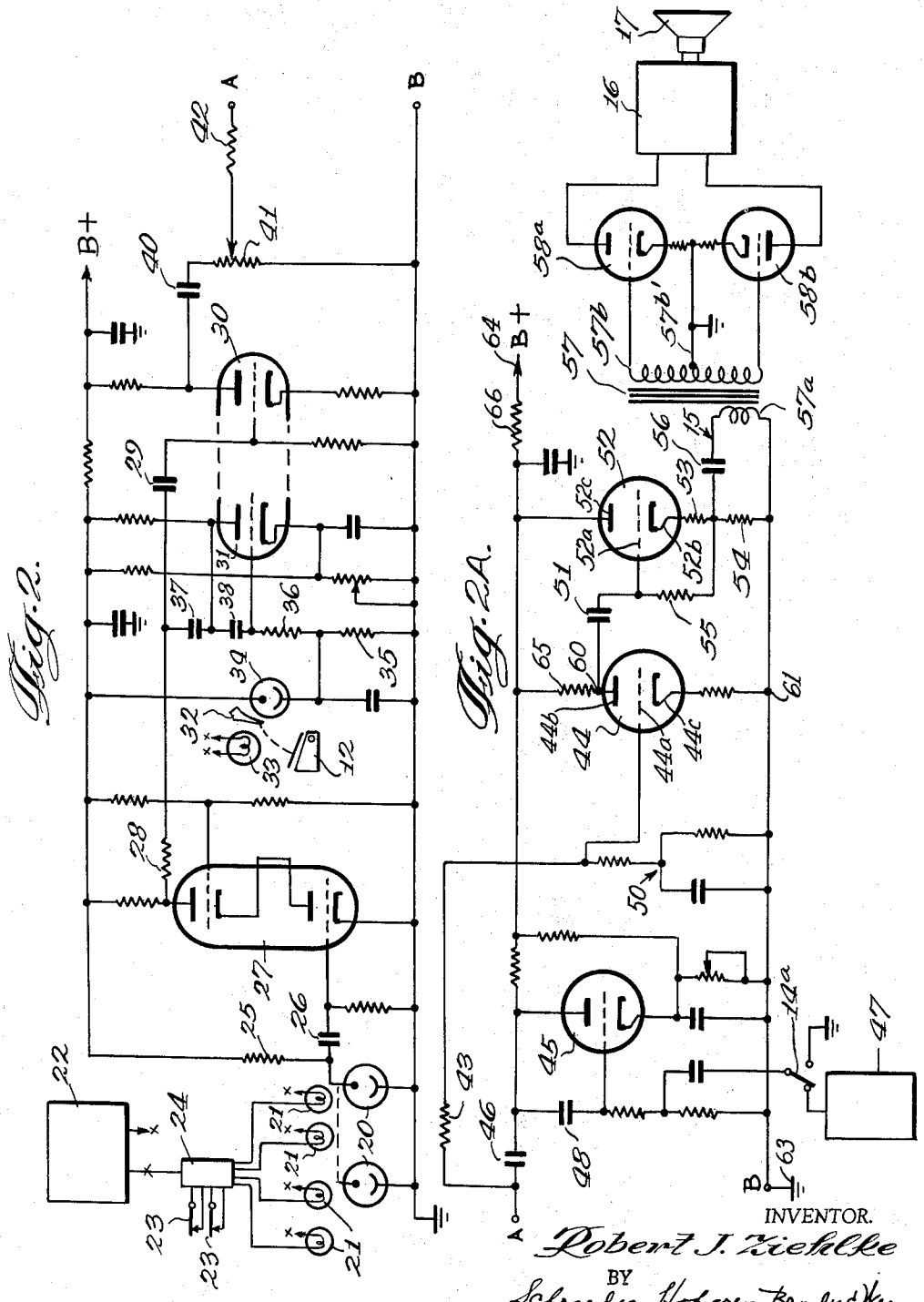


Fig. 2.

Fig. 2A.

INVENTOR.

Robert J. Ziehlke

BY

Schroeder, Hoffgren, Brady & Wegner

Attorneys

United States Patent Office 3,026,757 Patented Mar. 27, 1962

3,026,757

TRANSIENT FILTER

Robert J. Ziehlke, Janesville, Wis., assignor to Gibbs Manufacturing & Research Corporation, a corporation of Wisconsin

Filed Nov. 24, 1958, Ser. No. 775,893
1 Claim. (Cl. 84—1.19)

This invention relates to an electronic musical instrument and more particularly to a novel circuit for an electronic musical instrument, including filter means for reducing the relative amplitude of or eliminating objectionable transient effects.

This application is a continuation-in-part of copending Ziehlke application, Serial No. 745,564, filed June 30, 1958, and assigned to the assignee of this application.

In an electronic musical instrument, as an electronic organ, there are various devices in the signal handling circuitry which may introduce objectionable transient signals into the system, and it is extremely desirable that these transients be eliminated or reduced in amplitude so that they are not present to an appreciable degree in the output of the instrument. For example, in a preferred form of tone generator, which utilizes a plurality of selectively operable light bulbs or lamps in the generation of the tone representing signals, the thermal or incandescent characteristic of the lamps may give rise to a transient upon energization and deenergization of the lamps. Particularly in an electronic organ, a manually operable swell or volume control is provided; and in many swell control circuits, a transient is introduced corresponding in frequency with the rate of operation of the manual swell control. Furthermore, in many electronic organ systems, means are provided for producing a "tremolo effect" in which the amplitude of the tone representing signals is varied at a low or sub-audio rate, introducing a transient at the sub-audio rate. These transients have an undesirable effect if reproduced with the tones generated by the instrument and should be eliminated from the tone representing signal before reproduction.

A principal object of the present invention is the provision in an electronic musical instrument of a novel filter means for reducing the amplitude of objectionable transients relative to the amplitude of the tone representing signal.

One feature of the invention is the provision in an electronic musical instrument in which objectionable transients are introduced into the signal, at a frequency lower than the lowest frequency of the tone representing signal, wherein a high pass filter is connected to the output of a cathode follower for reducing the amplitude of the transients relative to the amplitude of the tone representing signal. Another feature of the invention is the filter which includes a capacitor connected in series with a winding of a coupling transformer, the capacitor and transformer forming a series resonant circuit at a frequency of the order of the lowest frequency of the tone generating means. A further feature is that the filter has an attenuation characteristic with a slope of the order of twelve decibels per octave at frequencies below the resonant frequency thereof.

Still another feature is that the transient filter is used in an electronic musical instrument having tone generating means including a plurality of selectively operable lamps, the light from the lamps being converted into an electrical tone representing signal, and the thermal characteristics of the lamps introducing objectionable transients into the tone representing signal. Yet a further feature is that the transient filter is used in an electronic musical instrument having circuitry including a swell

control circuit having a manually operable control, actuation of which produces an objectionable transient into the tone representing signal, and a selectively operable tremolo system including a variable impedance device controlled by a sub-audio oscillator and introducing an objectionable transient at the sub-audio rate.

Further features and advantages of the invention will readily be apparent from the following specification and from the drawings, in which:

FIGURE 1 is a block diagram of an electronic musical instrument embodying the invention;

FIGURES 2 and 2A are a schematic circuit diagram thereof;

FIGURE 3 is a curve illustrating the transient characteristic of a lamp; and

FIGURE 4 is a curve illustrating a characteristic of the transient filter.

In FIGURE 1 of the drawings, a block diagram of an electronic musical instrument, here an organ, is illustrated, having a plurality of tone generators **10**, the output of which is connected with a preamplifier **11**. The amplitude of the output signal from preamplifier **11** is controlled by means of swell control **12** with which the organist may control the ultimate volume of the generated tones. The signals from the preamplifier **11** are coupled to a further amplifier **13**, which is provided with a tremolo control **14** which may be rendered operative by the tremolo control switch **14***a*. The purpose of the tremolo is to impart to the signal a tremolant quality, i.e., a slight variation in amplitude, preferably above and below the normal amplitude of the signal, at a low or sub-audio rate. As will appear more fully below, certain characteristics of the various elements of the system, including tone generators and the swell and tremolo control circuitry may introduce into the tone representing signal a low frequency transient voltage which will have an undesirable effect on the fidelity of the instrument. In accordance with the present invention, a filter **15** is provided in the signal handling channel for eliminating or reducing the amplitude of the objectionable voltage with respect to the desired tone representing signal. The output of the filter is coupled with power amplifier **16**, and to a speaker system **17**.

Turning now to FIGURES 2 and 2A, a schematic circuit diagram of a musical instrument embodying the invention will be described in some detail. The circuits of FIGURES 2 and 2A are connected by terminals A—A and B—B. During the course of this description, tube types and component values for many of the elements of the system will be given. It will be understood that this specific information is given for the purpose of making a complete disclosure of an operative embodiment of the invention, and the values given are not to be considered critical, as many changes will be apparent to those skilled in the art.

Lamps **21** are energized from a suitable source of electrical energy **22**, which may, for example, have an output voltage of ten volts D.C. The connection of lamps **21** to the power source **22** is effected by key switches **23**, which may be associated with the keys of a standard instrument keyboard, through a stop selector means **24** for choosing the lamps associated with the desired tone patterns. The photocells **20** for each of the tone generators **10** (of which there may be twelve, one for each note in an octave) are connected in parallel and through a current limiting resistor **25**, 1 megohm, with a suitable B+ supply source. The tone representing signals are connected through capacitor **26**, 0.01 μf. (microfarad), to the control grid of a cascade connected dual triode amplifier **27**, a 12AT7.

The characteristics of the filament of lamps **21** are such that the lamps do not shift instantaneously to a full in-

candescent condition when the key switch is closed, nor do they drop instantaneously to a dark condition when the key switch is opened. As shown in FIGURE 3, a finite period t_1 is required between the instant the key is closed and the time at which the average D.C. level of the tone is achieved. Similarly, a finite period t_2 is required between the time the key is opened and the point where the output from the photocell due to light from the lamp become insignificant. During these transition periods, t_1 and t_2, transients are generated in the system which are a result of the shift in D.C. level across photocells **20**. The frequencies of the transients is dependent principally upon the thermal or incandescent characteristics of the filaments of lamps **21**, but primarily they are composed of low or sub-audio frequencies.

The output of cascade connected amplifier **27** is connected through a series resistor **28** and coupling capacitor **29** with the control grid of triode amplifier **30**, one-half of a 12AT7.

Shunted across the signal channel between amplifiers **27** and **30** is a swell control circuit including a variable impedance device **31**, one-half of a 12AT7. The conduction through device **31** is controlled by the swell pedal **12**, as will appear, varying the apparent impedance shunting the signal channel, and thus controlling the relative amplitude of the tone representing signals transmitted through the channel.

In a preferred embodiment of the system, swell control **12** actuates a mask **32** interposed between lamp **33** and a photocell **34** which is connected to resistor **35** in the circuit of the control grid of variable impedance device **31**. With the swell control pedal fully raised, i.e., minimum volume, the full light from lamp **33** shines on photocell **34** and it conducts heavily, applying a positive potential through resistor **36** to the control grid of tube **31**. In turn, tube **31** conducts heavily and appears as a low impedance to the signal channel. As the control pedal is depressed, mask **32** progressively cuts off the light from lamp **33** shining on photocell **34**, reducing the positive potential applied to the control grid of tube **31** and increasing its apparent impedance. When the swell pedal is fully depressed, the current through tube **31** is at a minimum and its impedance is a maximum, a condition of maximum signal volume.

As the swell pedal is operated and the current through tube **31** changes, the D.C. potential of the anode also changes at a rate dependent upon the speed of movement of the control pedal. A transient signal thus produced is coupled through capacitor **37**, 0.1 μf., to the signal channel. In an effort to reduce the relative amplitude of the transient signal, a feedback capacitor **38**, 0.004 μf., is connected between the anode and cathode tube **31**, providing a feedback signal. However, this feedback circuit cannot completely eliminate the transient effect, and a certain portion of the undesired transient is added to the tone representing signal in the signal channel.

Returning now to a consideration of the primary signal handling channel, the output of amplifier **30** is coupled through capacitor **40** to a manually operable level control potentiometer **41**. The movable tap for potentiometer **41** is connected through series dropping resistors **42** and **43**, to the control grid **44***a* of amplifier **44**, a 12AX7. Shunted across the signal channel between series resistors **42** and **43**, is a selectively operable tremolo circuit including a triode **45**, one-half of a 12AT7, whose anode is connected with the signal channel through capacitor **46**, 0.025 μf. The control grid circuit of tube **45** is selectively connectable with a sub-audio oscillator **47**, through tremolo control switch **14***a*. With switch **14***a* in the position shown in the drawing, connecting the sub-audio oscillator with the control grid circuit of tube **45**, to shunt impedance of the stage is varied at the frequency of the oscillator, which may be, for example, four or five cycles per second. The tremolo circuit operates in a manner similar to the swell control circuit, varying the shunt impedance presented to the signal channel, and thus varying the relative amplitude of the tone representing signal. Furthermore, as in the swell control circuit, the operation of the tremolo introduces transient signals into the signal handling channel, here basically at the frequency of the sub-audio oscillator. Again, a feedback circuit including capacitor **48**, 0.01 μf., is connected between the anode and the control grid of tube **45** in an effort to reduce the transient effect, but it is not completely eliminated.

The amplifier **44** includes an anode **44***b* connected to an output terminal **60** and a cathode **44***c* connected to a terminal **61** by a resistor **62**. The terminal **61** is connected to the grounded negative supply terminal **63**. The terminal **60** is connected to a positive supply terminal **64** by resistors **65** and **66**.

A bass boost circuit **50** is shunted across the input of amplifier **44** and the output of the amplifier is connected through capacitor **51** with the control grid **52***a* of cathode follower tube **52**, one-half of a 12AT7. The cathode **52***b* of the cathode follower tube is connected to ground potential by a load resistance which is divided into two portions, a grid bias resistor **53**, 1000 ohms, and an output load resistor **54**, 33,000 ohms, with the output potential being derived across resistor **54**. The control grid is returned through resistor **55** to the juncture of the resistors **53** and **54** providing some degenerative feedback. The anode **52***c* of the cathode follower tube is connected to the positive supply terminal **64** by the resistor **66**. The output of the cathode follower is coupled through capacitor **56** to the primary winding **57***a* of coupling transformer **57**. The secondary winding **57***b* of coupling transformer **57** has a grounded center tap **57***b'* and provides two signals, 180° out of phase with each other, for push pull driver amplifiers **58***a* and **58***b*, the two halves of a twin triode, 12AU7. The output of drivers **58***a* and **58***b* is coupled to power amplifier **16** and from there to speaker **17**.

As is apparent from the foregoing discussion, the various elements of the signal generating and handling system have the incidental and undesirable effect of introducing certain transients into the tone representing signal generated and handled by the system. Furthermore, the principal energy of these transient signals is in an extremely low frequency range; and at least those transients generated by the tremolo circuit are primarily the sub-audio frequency of the tremolo oscillator **47**.

In accordance with the present invention, a filter network is incorporated in the signal channel to reduce the relative amplitude of the undesirable transient frequencies. In the illustrated embodiment of the invention, capacitor **56** forms a series resonant circuit in the input of coupling transformer **57**. The resonant frequency of the filter circuit is preferably of the order of or slightly higher than the frequency of the lowest generated tone. In a specific embodiment of the system where lowest generated tone has a frequency of 16 c.p.s., the resonant frequency of the filter is 32 c.p.s. For this resonant frequency, capacitor **56** has a value of 1.25 μf, and the input of transformer **57** an apparent inductance of the order of 20 henries. The transfer characteristic of filter **15** is illustrated in FIGURE 4, where the ratio of the output voltage to the input voltage of the filter is plotted as a function of frequency. It will be noted that the characteristic has a slight peak at the resonant frequency f (here 32 c.p.s.), and then drops off rather rapidly. The slope of the attentuation characteristic of the filter below the resonant frequency f is preferably of the order of twelve decibels per octave, so that the low transient frequencies are highly attentuated. For example, the tremolo frequency from sub-audio oscillator **47** is about three octaves below the resonant frequency of the filter, and is attenuated 36 decibles below the level of the tone representing signals.

While I have shown and described certain embodiments

of my invention, it is to be understood that it is capable of many modifications. Changes therefore, in the construction and arrangement may be made without departing from the spirit and scope of the invention as disclosed in the appended claim.

I claim:

In a musical instrument of the type in which first and second tone signal terminals have applied thereto musical tone signals extending over a range of several octaves together with undesired transient noise substantially lower in frequency than the lowest pitch tone signal and in which a positive and a negative supply potential terminals are connected respectively to the first and second tone signal terminals, in combination with the terminals, a cathode follower including an electron discharge tube having an anode connected to the positive supply potential terminal, a grid connected to the first tone signal terminal, a cathode, and a load resistor connecting the cathode to the second tone signal terminal; a voltage gain coupling transformer having a primary winding and a secondary winding; and a capacitor connected in series with the primary winding and forming with the primary winding a series resonant circuit having a resonant frequency approximately equal to the pitch of the lowest pitch musical tone signal, the series connected capacitor and primary winding being connected across the load resistor to induce voltage amplified tone signals in the secondary winding and to substantially attenuate the low frequency transient noise.

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UNITED STATES PATENT OFFICE

CERTIFICATE OF CORRECTION

Patent No. 3,026,757 March 27, 1962

Robert J. Ziehlke

It is hereby certified that error appears in the above numbered patent requiring correction and that the said Letters Patent should read as corrected below.

Column 2, line 56, before "Lamps 21" insert the following:

> A preferred form of tone generator 10 is indicated schematically in Figures 2 and 2A, each tone generator including a photocell 20 having a plurality of selectively operable light sources or lamps 21 associated therewith. The light from lamps 21 is utilized to form tone signals in a well known manner.

column 3, line 71, for "to" read -- the --.

Signed and sealed this 10th day of July 1962.

(SEAL)
Attest:
ERNEST W. SWIDER
Attesting Officer

DAVID L. LADD
Commissioner of Patents